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THE BEGINNINGS OF HUMAN HISTORY READ FROM THE GEOLOGICAL RECORD: THE EMERGENCE OF MAN[1]

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PART TWO

GEOLOGICAL HISTORY OF MAN

HAVING considered the biological position of man and the possibility of his ancestry leading out of the evolution of presumably inferior, and certainly older primate groups, we are in a favorable position for discussion of the earliest evidences of man himself; but before entering upon consideration of the specific problem of human history, it is well to bring to mind certain of the most fundamental conclusions obtained in an inspection of the wide field of history of other living creatures. To one who reads this story, the evidence of the geologic and paleontologic series amounts to a demonstration that our available records of life in the broadest view count up to many tens of millions of years at the least, and possibly reach to hundreds of millions. We see also that in this period the record shows life to have been in an almost continuous state of change; that the life of each period exhibits closer resemblance to that of the periods immediately preceding and following than to the more remote divisions of time; and that series of forms with certain common characters but differing in grade of specialization generally tend toward greater specialization from earlier to later time. The manner in which the modifications take place may not always be understood, and the paleontologist may admit his ignorance of the causes, but the evidence of continuing change and advancing specialization in series of presumably connected or related types seems reasonably clear.

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[1] Delivered before the National Academy of Sciences in April, 1918, as the sixth series of lectures on the William Ellery Hale Foundation.

Well within the generally accepted record of the geologist, and forming a part of the life succession of the paleontologist, there appears the human element, taking its place in the life sequence and raising, whether we desire it or not, the question of man's inclusion in the general scheme of evolution, or if his relation to the other biological series, for which we have traced a long history and through which we seem to see running the thread of continuity.

From what we have seen in our paleontologic record there is every reason to believe that there was a long period in which generalized members of the mammalian group were widely distributed and man had not yet appeared. Unless we take the view that man is the product of special creation, built upon lines similar to those of other organisms, we naturally assume that his origin is found in the earlier less specialized type, and by way of an evolutionary process not unlike those that have determined the development of other mammalian forms by modification of types already existing.

THE EARLIEST REMAINS REFERRED TO THE HUMAN TYPE

DISCOVERY OF PITHECANTHROPUS

For the present we shall consider only those relics of man which furnish the earliest known record of the existence of our race upon the earth, leaving for a later paper an account of the succeeding stages represented by the cave men and their immediate predecessors.

Probably no paleontologic contribution published has furnished the basis for more extended and more critical discussion than the paper of Eugene Dubois published in 1894, describing a remarkable tooth, a skull-cap and a thigh bone, found in deposits of considerable geologic antiquity on the island of Java. These specimens presumed to represent a single type, and probably one individual, were first referred to by Dubois in 1892 as *Anthropopithecus erectus* or the erect man ape, assumed to represent a transition between man and the apes. After having with most commendable patience investigated his material for three years, Dubois published his now classic memoir. In this paper the specimens were referred to as *Pithecanthropus.* or ape man, this generic name having been used by Haeckel in 1868 for a hypothetical creature assumed to walk erect, and to have higher mental development than the anthropoids, although not yet attaining to the formulation of speech.

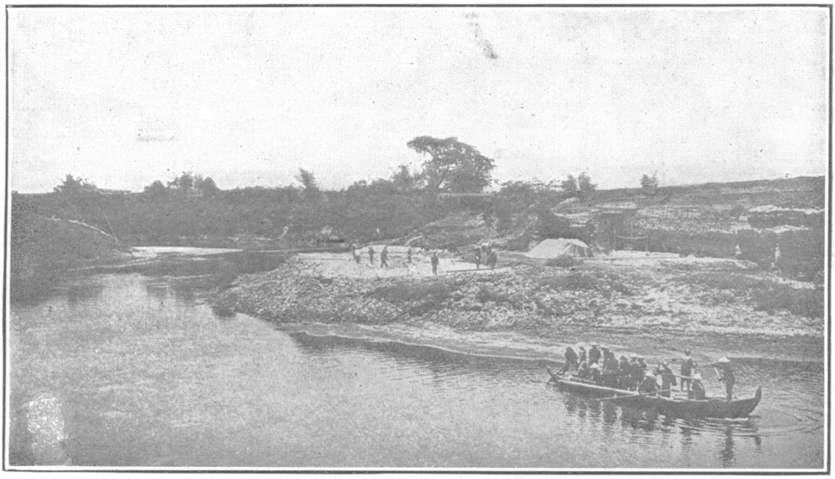

FIG. 1. Locality at which *Pithecanthropus* Remains were discovered on the Bengawan River in Java. After L. Selenka and M. Blanckenhorn.

Following this work of Dubois, extensive excavations initiated by Frau Selenka were carried on in 1907 and 1908 on the site of the occurrence of the type specimen. These important studies added much to our knowledge of the formation in which the Dubois specimen was found, and of the fauna associated with it, but did not contribute additional *Pithecanthropus* remains.

OCCURRENCE AND ASSOCIATED FAUNA

The specimens referred to *Pithecanthropus* all exhibited approximately the same mode of preservation, which is similar to that of the extinct types of mammals found in the same strata, and which have clearly been buried in process of accumulation of the formation. There was no evidence indicating intrusion or burial of these remains in the formation since accumulation, and the relation of the Dubois specimen to the stage of geologic time represented by the deposits containing the mammalian fauna is not seriously questioned.

Some doubt has been expressed, however, whether the skull-cap, the femur, and the teeth belong to the same individual. The first tooth and the skull-cap were found in 1891 only about three feet apart. The femur, discovered the following year, was situated nearly fifty feet from the location of the skull. Inasmuch as the femur is by some considered quite human in aspect, while the skull-cap is assumed to be pre-human, question has naturally been raised as to the relation of these elements to each other. On the other hand, the fact that skull, teeth and thigh bone occurred approximately together, with similar mode of preservation, and with peculiar characters differing from those of all known anthropoids and humans, is considered by many as evidence distinctly favoring the view of Dubois that the specimens all represent one species and one individual. It will evidently not be possible to settle this question with full satisfaction until further occurrences of remains of this most interesting type are discovered.

The *Pithecanthropus* specimens were found in a formation composed in large part of volcanic tuff. It was considered by Dubois as a river accumulation and was assumed by him to have a total thickness of over 1,000 feet. The results of the Selenka expedition indicated that the so-called *Pithecanthropus* layer, containing bones of many extinct animals, owes its origin to the gradual working over of ash beds formed through eruption of great volcanoes near at hand. In the course of the eruption many animals were destroyed and the remains buried in ashes. Rain wash worked over the ashes and the entombed bodies of animals. The bones washed out were later accumulated at points where swamps or comparatively level stretches in the stream stopped transportation of heavy objects by slowing of the current.

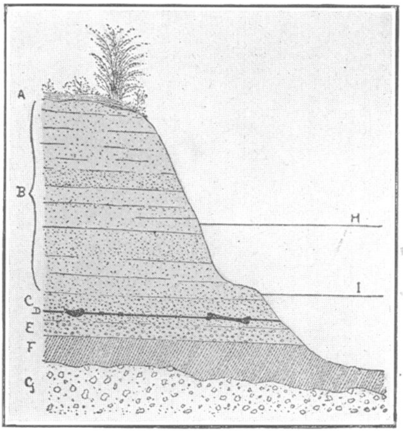

FIG. 2. Section of Strata at the Locality where the *Pithecanthropus* Bones were discovered. *A*, area of growing plants; *B*, soft sandstone; *C*, lapilli stratum; *D*, level at which the skeletal remains were found; *E*, conglomerate; *F*, argillaceous layer; *G*, marine breccia; *H*, wet-season level of the river; *I*, dry-season level of the river. After E. Dubois.

The particular layer in which the *Pithecanthropus* specimens were discovered, was found by Dubois and by the Selenka expedition to contain a large number of remains of mammals, representing at least thirty species. These include the pre-elephant, or *Stegodon,* which is the immediate ancestor of the modern elephant, also cats, hyenas, rhinoceros, tapir, pig, hippopotamus, deer, buffalo and monkeys. Along with the mammals was a considerable variety of reptiles, among which were crocodiles, gavials, lizards, snakes and turtles.

The mammal fauna of the *Pithecanthropus* beds resembles in many respects that of the Java region of the present day, but practically all of the species are extinct. Certain forms, as *Stegodon,* are generally characteristic of the Pliocene, the second period preceding the present. The mammal assemblage as a whole is very close to that of southern Asiatic formations representing a stage near the close of the Pliocene, as seen in certain of the later levels of the Siwalik series in India. As mammal faunas are generally short-lived in the geologic sense, there seem good reasons for considering that the beds containing *Pithecanthropus* and the associated mammal remains were deposited at a period approximately the same as the late Pliocene on the early part of the next stage, the Pleistocene as recognized in other formations of which the age has been clearly determined (see Fig. 7).

Suggestions regarding age of the beds have also been made by Blanckenhorn on the basis of climatic conditions obtaining during accumulation of the deposits. Abundant plant collections secured in the formation containing *Pithecanthropus* indicate to practically all investigators who have examined them a much more humid climate than that now found in this region, and perhaps a temperature five or six degrees colder. Considering the Glacial Epoch to have been a time of relatively high humidity, Blanckenhorn believed the available evidence indicative of a time stage for the *Pithecanthropus* beds corresponding approximately to the first or Günz stage of glacial time, or near the beginning of the Pleistocene period.

NATURE OF REMAINS

Study of the remains of *Pithecanthropus* has been carried to an extreme of detail rarely reached in investigation of other known specimens. It is only regrettable that this work, so far as it has been done by workers other than Dubois, has been based largely upon casts of the originals rather than upon the specimens themselves.

The *tooth* first found is of extraordinary size, and quite different from the corresponding third upper molars of human

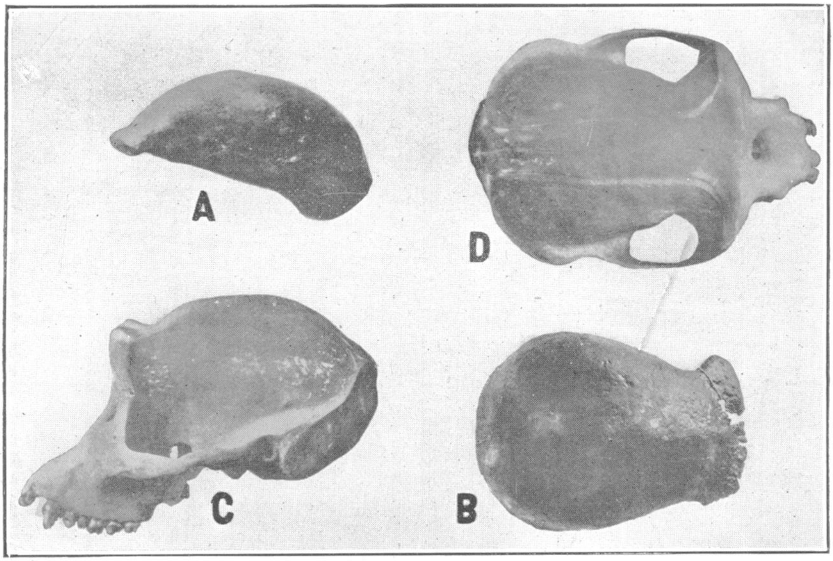

FIG. 3. *Pithecanthropus erectus,* Skull cap Compared with Skull of a Modern Chimpanzee. After E. Dubois. *A, Pithecanthropus* skull cap seen from the left side, × 1/3; *B,* same specimen seen from above; *C,* chimpanzee skull from the left side, × 4/9; *D,* skull seen from above.

beings. It either represents a large individual, or an individual with relatively large and heavy teeth.

The *skull-cap* has been examined from almost every possible angle of physical or mental vision by a great group of investigators, and is by common consent a most unusual type, bearing in general the characters of a human being, but more beast-like than any human species recent or extinct. The vault of the cranium is low, and the arch is flat both on the forehead and on the back of the skull. The eyebrow ridges are very prominent, as in the apes, and the skull is narrow behind the eyes. The brain capacity is lower than that of normal human types. Measurements of the cranial capacity given by Dubois have approximately 900 cubic centimeters, while the corresponding measurement of anthropoids rarely reaches 600 c.c., and of male Caucasian humans approximately 1,500 c.c.

From the interpretation of this specimen, it is evident that *Pithecanthropus* represents a type previously unknown in either the human or the anthropoid group. It differs from the apes in its larger brain capacity coupled with reduced musculature relating to the jaws. It differs from man in its lower brain capacity and more beast-like contour of the skull. If there is justification for the assumption that the large teeth pertain to the same individual as the skull-cap, there seems sufficient warrant for accepting an ape-like reconstruction of the face with the large protruding jaws needed to support large teeth.

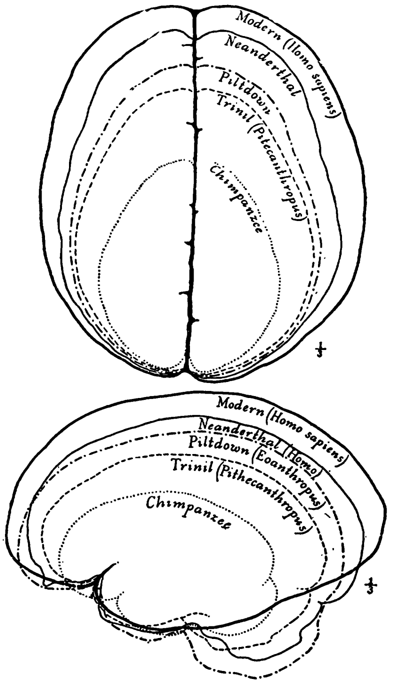

FIG. 4. Diagram showing Outlines of the *Pithecanthropus* Brain compared with that of the Chimpanzee and Certain Human Types. Upper figure, outline seen from above; lower figure outline seen from side. After Osborn, "Men of Old Stone Age," Charles Scribner's Sons.

Many restorations of the skull have been made, among which one of the most interesting is that by Dubois, showing

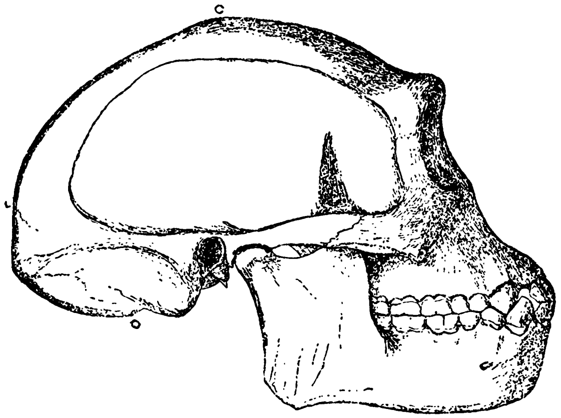

FIG. 5 Reconstruction of the *Pithecanthropus* Skull, x 1/3. After E. Dubois.

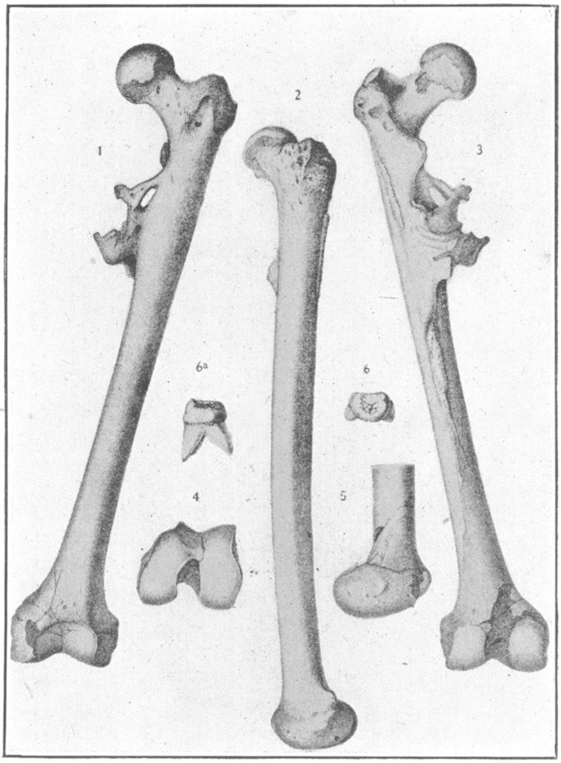

FIG. 6. Femur and Tooth of *Pithecanthropus*. 1, Femur from above; 2, from side; 3, from behind; 4, from below; 5, lower end from median side; 6, Right third upper molar from below; 6*a*, from behind. Much reduced. After Dubois.

the low-vaulted skull, prominent eye ridges, heavy jaws, and protruding facial region.

The *thigh bone*, found at the same level with the skull, resembles the corresponding bone of typical humans in some respects more closely than the skull resembles the cranium of human types. It approaches the human femur and differs generally from that of apes in its length, slenderness and straightness of shaft, as in other minor details. It is in fact more slender in some respects than the thigh bone of modern races. Resemblance to the femur of modern man is not, however, in any sense complete. Dubois has called particular attention to the more nearly circular cross-sections of the bone, and to distinct differences in certain important areas of muscle attachment. To a slight extent the peculiarities of the *Pithecanthropus* femur resembles those of the gibbon, but they do not correspond fully to gibbon characters.

This thigh bone cannot conceivably belong to an animal of the ape type. The form of the shaft and the nature of the articulations at the distal end are different from these features in apes. They show that the animal evidently walked with a degree of erectness comparable to that of typical humans, and that it must have possessed a length of limb and extent of stride in locomotion comparable to that of modern forms. This character of specialization for running or walking is not naturally combined with specialization of the anterior limbs for climbing, and we may safely assume shortness of arm like that of humans, and different from the type of limb in arboreal anthropoids.

Dubois and others have considered that the degree of deviation in form of the femur away from that of normal modern man and from the apes corresponds approximately to the extent of difference between the skull-cap of *Pithecanthropus* and that of both typical apes and typical men.

SYSTEMATIC POSITION

To the gratification of a large group of scientists, not long after publication of his memoir on *Pithecanthropus,* Dubois appeared with his specimens before the Zoological Congress at Leyden, where there occurred one of the most interesting discussions on the history of man that has ever taken place. Divergence of opinion as to significance of the remains lay largely in the question of classification. Five of the noted authorities, including Virchow, considered the animal to represent an ape; seven, including Cunningham, Lydekker and Topinard, considered it a man; and seven others, including Dubois, Manouvrier, Marsh and Haeckel, considered it a transition form.

With the wide knowledge of structure of man and of apes possessed by all of the eminent students whose opinions were expressed, it is clear that the essential difference lay in the definition of diagnostic characters of humans and apes. It is also evident that opinion of the group as a whole indicates the intermediate position of Dubois's find between typical humans and typical anthropoids. Centering upon the controversy over Dubois's specimens there has developed a discussion as to definition of hominid and anthropoid characters. There seems now to be practical unanimity of view that the essential distinctions lie in possession by man of somewhat greater brain capacity, erect position, length of limb, freedom of arm and hand from locomotion, and perhaps in possession of speech with sentence construction. These characters are contrasted with

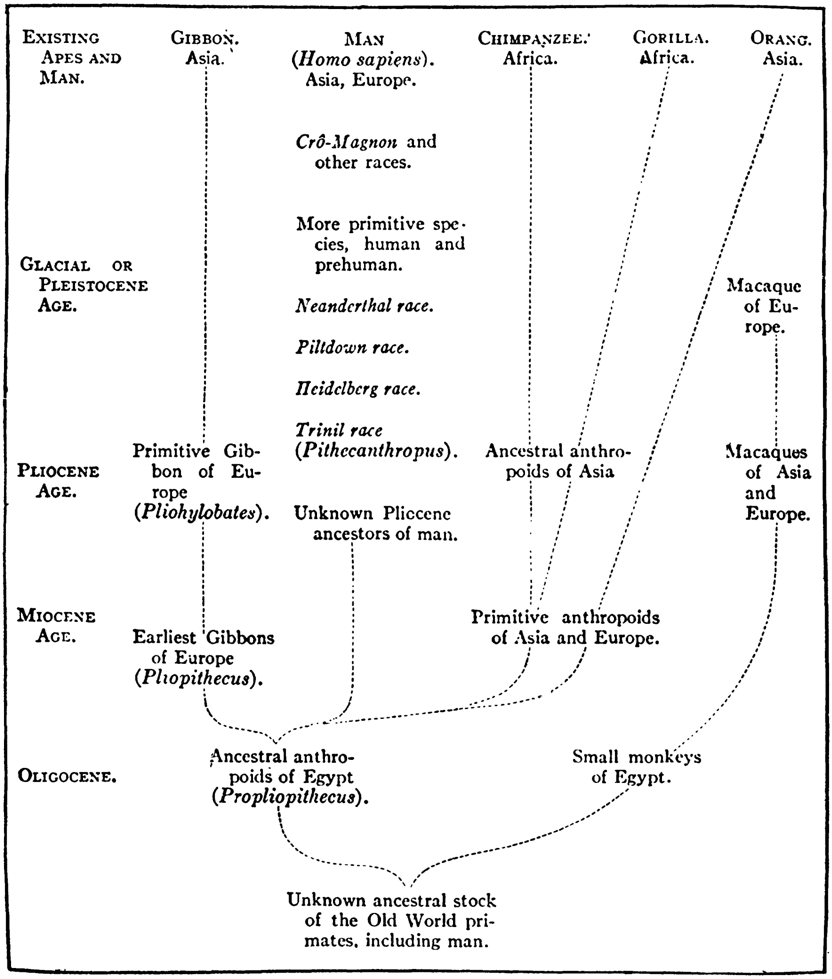
EXISTING APES AND MAN.
GIBBON. Asia.
MAN (Homo sapiens). Asia, Europe.
CHIMPANZEE. Africa.
GORILLA. Africa.
ORANG. Asia.
Crô-Magnon and other races.
More primitive species, human and prehuman.
GLACIAL OR PLEISTOCENE AGE.
Macaque of Europe.
Neanderthal race.
Piltdown race.
Heidelberg race.
Trinil race (Pithecanthropus).
Primitive Gibbon of Europe (Pliohylobates).
Ancestral anthropoids of Asia
Macaques of Asia and Europe.
PLIOCENE AGE.
Unknown Pliocene ancestors of man.
MIOCENE AGE.
Earliest Gibbons of Europe (Pliopithecus).
Primitive anthropoids of Asia and Europe.
OLIGOCENE.
Ancestral anthropoids of Egypt (Propliopithecus).
Small monkeys of Egypt.
Unknown ancestral stock of the Old World primates, including man.

FIG. 7. Outline of the Evolution of Anthropoid Apes and Man. After Osborn, "Old Stone Age," Charles Scribner's Sons.

the smaller brain, more prominent face, relatively short grasping posterior limbs, and long anterior limbs used for climbing, seen in apes. Judged according to this definition, it is evident that Dubois's specimen represents a stage just above the middle territory between man and the apes. The animal seems particularly human in its limbs and pre-human, with strong anthropoid tendencies, in the skull.

RECONSTRUCTION

A reconstruction of the skeleton based upon skull-cap, teeth and femur of *Pithecanthropus* makes necessary the organization of an animal with upright position and long straight limbs. There can be little doubt that with this structure of limb the foot must have been much as in modern man and the great toe much enlarged. With such limbs, the anterior extremities would be released from the burden of work in locomotion and come to serve the head alone. The large teeth make heavy jaws and a prominent face almost a certainty. The small brain case and prominent rims of the orbits give the combination of pre-human and super-anthropoid characters required by the long-sought missing link. If, as Dubois assumes, we are correct in relating these three classes of characters in one skeleton, there is little required to give the picture of a transition form as visualized by those who have foreseen the discovering of an ancestor of man coming out of the animal world.

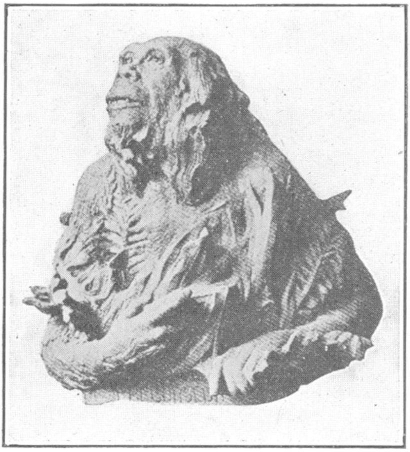

FIG. 8. Reconstruction of *Pithecanthropus* according to the Belgian Artist Mascré, under the direction of Professor A. Rutot. After Osborn, "Old Stone Age," Charles Scribner's Sons.

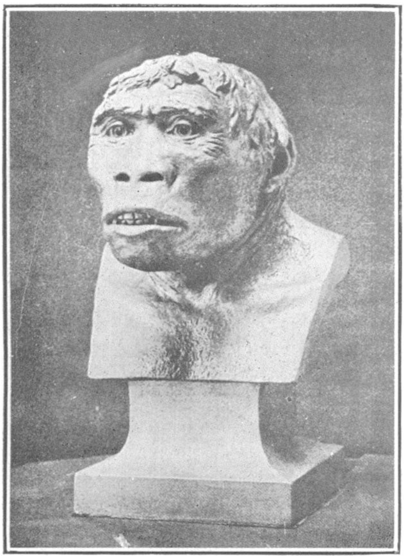

FIG. 9. Reconstruction of *Pithecanthropus* from the Restoration modeled by J. H. McGregor. After Osborn, "Old Stone Age," Charles Scribner's Sons.

Although the remains of the Java man are most unfortunately fragmentary, it is worthy of note that the long discussions which have focused on these specimens have left us with a remarkable unanimity of opinion as to the nature of the type. It is one of the most significant facts in the whole range of paleontological study, that these earliest known remains referred to the human group seem without question to represent the type farthest from modern humans and nearest to the anthropoids. The gap between the modern man and the modern apes is not fully bridged. It is perhaps worth stating that it will be difficult to define "fully bridging." The views as to what would constitute transition or "exactly intermediate stage" would probably vary with different investigators. It is, I think, quite certain that for the particular stage of geologic time in which it lived *Pithecanthropus* comes as near as we could well imagine to the expected intermediate form.

THE HEIDELBERG JAW

OCCURRENCE AND ASSOCIATED FAUNA

The second and perhaps the more important find of the two earliest known occurrences of remains referred to the human group is that known as the Heidelberg jaw. This specimen was obtained by Schoetensack, as the reward of twenty years persistent and continuous effort to learn whether traces of man might be found associated with the remains of extinct mammals at a locality in the Elsenz Valley not far from Heidelberg. From a sand pit Schoetensack had obtained many remains of extinct mammals of a stage sufficiently late in geological time to come within the assumed period of human evolution. Schoe-

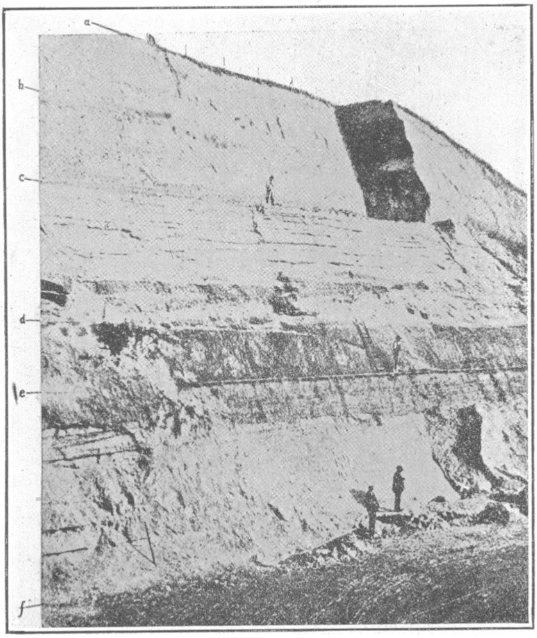

FIG. 10. Locality at which the Heidelberg Jaw was found, at a Depth of 79 feet below the Surface. The white cross in the lower right hand corner of the picture indicates the occurrence of the jaw. After O. Schoetensock.

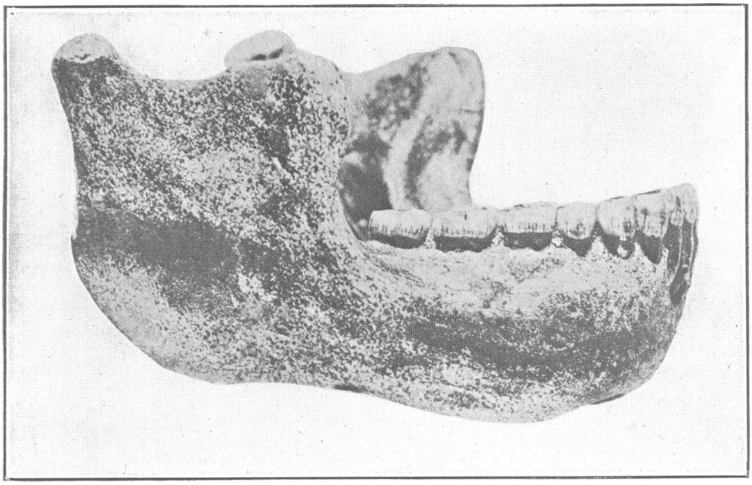

FIG. 11. Lateral View of the Heidelberg jaw, approximately two-thirds natural size. After Schoetensack.

tensack had repeatedly impressed upon J. Rösch, who worked at the pit, the importance of a possible find of human remains, and with the desirability of immediate and careful handling of any specimens suggesting man, should they appear. When in 1907 one of the workmen shoveled out a jaw of human type from a depth of approximately seventy-nine feet, the arrangements of long standing were favorable for rapid and trustworthy determination of the conditions of occurrence of this, one of the most remarkable known relics furnishing information bearing upon early human history.

The pit in which the famous jaw was found is cut into deposits consisting mainly of a formation known as the Mauer sands. At this locality the beds are about eighty-two feet in thickness. Between twenty-five and thirty feet of the upper portion of the deposits represent two formations known as loess. Below this upper section are the Mauer beds consisting mainly of sand and gravel. The human jaw was found only a little less than three feet from the base. The layer in which it was discovered was mainly gravel which was found to contain remains of extinct mammals characteristic of the Mauer beds. The condition of the undisturbed layer from which the jaw was taken leaves no room for doubt that all of the fossil remains, including the human jaw, were deposited at the same time with the sand and gravel making up this lowest portion of the formation.

The fauna found in the formation comprises not less than fourteen mammalian species, including the Etruscan rhinoceros, a species of horse, a primitive elephant (*Elephas antiquus*), a large lion (*Felis leo fossilis*), and remains of bear, deer, pig, and bison.

Schoetensack held that the Mauer fauna showed relationship to the early glacial or inter-glacial forest bed of Norfolk, as also to the Pliocene. The rhinoceros and the horse were considered especially significant of the earliest Pleistocene or Pliocene. Schoetensack placed particular stress upon the possibility that the jaw was the earliest authentic skeletal representative of the human group. Other investigators have considered the formation in which the Heidelberg jaw was found as considerably later and representing the second or Mindel-Riss inter-glacial stage.

DESCRIPTION OF REMAINS

The Heidelberg jaw undoubtedly constitutes one of the most interesting remains of early man thus far discovered. In comparison with all modern human types, it is characterized by its unusual size, lack of protruding chin, great strength and thickness of the body of the jaw, and unusual width of the area for the attachment of the muscles used in mastication. It is also characterized by the extraordinary form of the inner side of the anterior region of the jaw in an area marked by the attachment of certain muscles having an important relation to movement of the tongue in speech. The teeth are large, but not relatively large compared with the size of the jaw, and are notably human in practically all characteristics. While the jaw without the teeth might not have been called human, the teeth without the jaw would certainly have been assumed to represent a human type not differing greatly from known species.

The teeth are characterized by strength of the roots and large size of the pulp cavities; but considering their relation to the peculiar primitive type of jaw in which they are situated, the most striking characteristic of the dentition is probably the small, distinctly human canine. Comparison of the human dentition with that of the apes brings out the fact that humans are distinguished by limitation of the canines to such dimensions that the crowns of these teeth show approximately even length with those of their neighbors. In the apes, as in many other groups of mammals, the canines are very prominent, projecting far beyond the level of the neighboring teeth, and having an important function in tearing food or in fighting. It has been assumed that primitive humans and intermediate types between man and other mammals would naturally be characterized by somewhat larger canines than those of modern species. In a jaw showing the massiveness, strength and primitiveness of the Heidelberg specimen, it would be natural to expect a canine of somewhat greater size than that of modern human types, whereas, as indicated, this tooth is here reduced to dimensions comparable to those of advanced modern types. It seems, therefore, that reduction of the canine to dimensions comparable to those of other teeth in the front of the jaw is one of the most significant characteristics of the early human type.

As shown in comparison of an Eskimo, the Heidelberg jaw, and a chimpanzee, the combination of characters in the Heidelberg specimen is more like that of the anthropoids than is the combination known in other forms referred to the human group. While the dentition in general is distinctly human, the size of the teeth, compared with those of many modern types, with the heavy roots and wide pulp cavities present characters which point toward an ancestral type resembling the anthropoids in some measure.

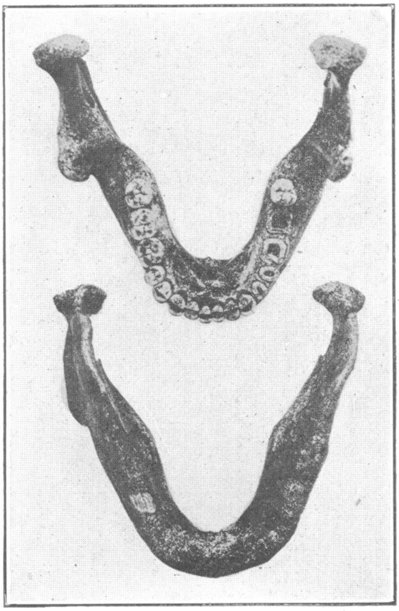

FIG. 12. Upper and Lower Views of Heidelberg Jaw, slightly exceeding one half natural size. After Schoetensack.

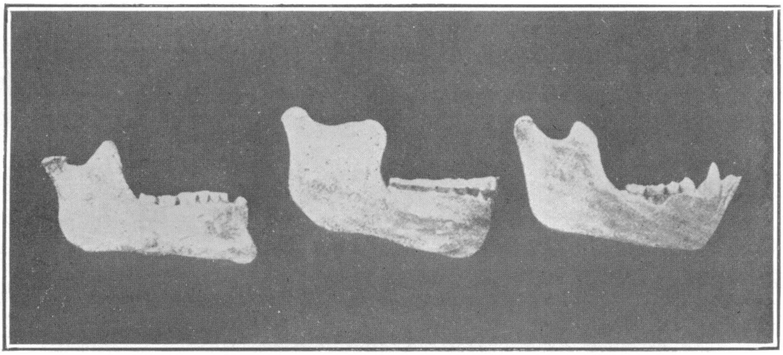

FIG. 13. Comparison of Heidelberg Jaw, in the middle of the picture, with a Modern Anthropoid to the right and an Eskimo to the left. After Osborn, "Old Stone Age," Charles Scribner's Sons.

In the configuration of the inner side of the jaw, there are strong evidences indicating that the musculature was different from that of modern man endowed with peculiar characters of the tongue related to speech.

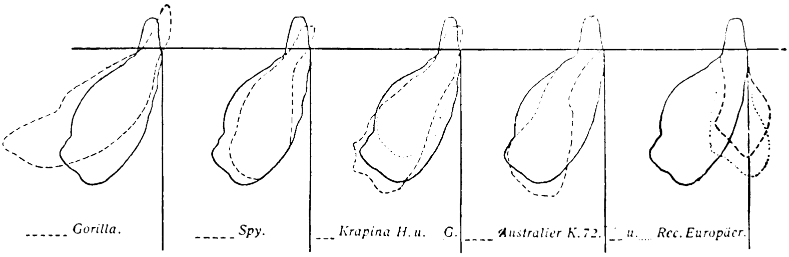

FIG. 14. Comparison of Vertical Sections through the Chin Region of the Lower Jaw. The sections of the Heidelberg Jaw are drawn in heavy line. The jaws with which comparison is made are indicated in broken lines.

The upper dentition and skull of the Heidelberg man have been reconstructed with great care by Dr. J. H. McGregor, and show a form resembling that of *Pithecanthropus* in many respects, but somewhat less ape-like. The teeth are smaller than those of *Pithecanthropus*. The face was probably less prominent and the brain capacity presumably greater.

SIGNIFICANCE OF THE HEIDELBERG JAW

The stratigraphic position of the beds from which the Heidelberg or Mauer jaw was obtained has not been questioned. The associated fauna has been known at a considerable number of other localities, so that the occurrence of this specimen is defined as that of a form living in middle or early Pleistocene time, with certain suggestions of Pliocene stage. The age of the *Pithecanthropus* specimen has been the subject of much discussion, and is considered by some to represent a stage only a little earlier than that of the Mauer jaw. The association of the *Pithecanthropus* skull-cap, teeth, and femur as parts of one individual or one species has also been questioned. While it may be that the Java specimens represent the same individual, it is also within the range of possibility that they represent two or three distinct types. Though great interest attaches to the discovery of *Pithecanthropus,* and to the speculations concerning the nature of the creature or creatures represented by this find, it is possible that the unquestionably primitive Mauer jaw, occurring in undoubted association with an early Pleistocene fauna and in a somewhat more definite geological situation, represents the most important and perhaps the earliest of the known human remains.

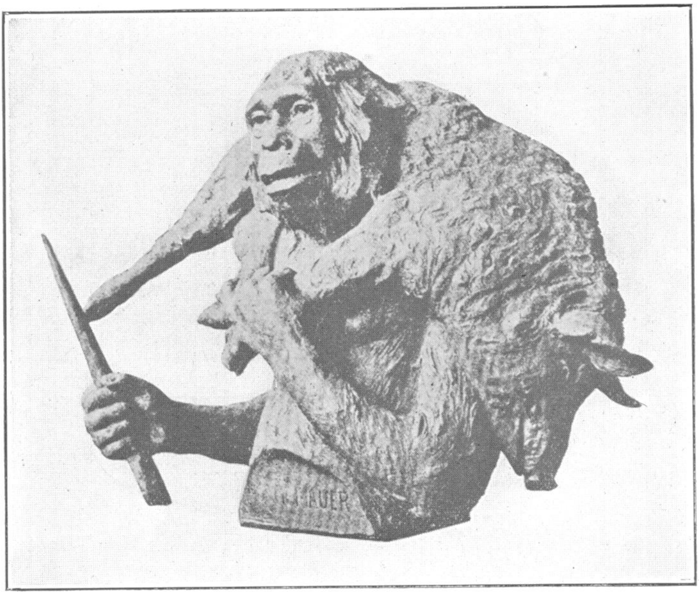

FIG. 15. Restoration of the Heidelberg Man by the Belgian Artist Mascré under the direction of Professor A. Rutot. After Osborn, "Old Stone Age," Charles Scribner's Sons.

POSSIBLE TRACES OF ARTIFACTS PRODUCED BY EARLIEST KNOWN HUMANS, THE EOLITHIC CULTURE

Assuming that two of the essential characters separating the hominid group from the anthropoids are found in the free-

SYSTEM OF CHRONOLOGY FOR THE STONE AGE

(ADAPTED FROM RUTOT)

RECENT			NEOLITHIC	*Present Fauna.*	Robenhausian. Campignian and Tardenoisian. Tourassian.
QUATERNARY	FOURTH GLACIAL PERIOD	Retreat.	PALEOLITHIC PERIOD	*Fauna of the Reindeer.*	Tarandian Industry.
		Advance.			
	THIRD GLACIAL PERIOD	Retreat.		*Fauna of the Mammoth (Elephas primigenius).*	Eburnean Industry.
		Advance.			
	SECOND GLACIAL PERIOD	Retreat.			Mousterian Industry.
		Advance.			Acheulian Industry. Chellean Industry. Mesvino-chellean or Strépyan Industry (Strépy, Belgium).
	FIRST GLACIAL PERIOD	Retreat.	EOLITHIC PERIOD	*Fauna of Elephas antiquus.*	Mesvinian Ind. (Mesvin, Belgium). Reutelo-mesvinian or Mafflean Industry { Maffle near Ath, Belgium.
		Advance.			Reutelian Industry (Reutel, Belgium).
TERTIARY	PLIOCENE	Upper.		*Fauna of E. meridionalis*	Ind., Cromer Forest Bed (Norfolk). Industry of Dewlish (Dorset). Industry of Saint-Prest (France).
		Middle (Glacial.)			Industry of the Chalk Plateau (England).
		Lower.			
	MIOCENE	Upper.		*Fauna of Dinotherium*	Industry of Puy-Courny (France).
		Middle Lower.			
	OLIGOCENE	Upper.		*Fauna of Acerotherium*	Industry of Thenay? (France).
		Middle Lower.			
	EOCENE				

FIG. 16. System of Chronology in the Stone Age. After MacCurdy.

ing of the anterior extremities to serve the head and in the development of intelligence to make possible a wide variety of uses for the anterior extremities, one naturally considers the making of implements or artifacts as a characteristic which should be distinctive of humans. Question has therefore arisen whether the *Pithecanthropus* and Heidelberg types had reached a stage at which natural objects were regularly worked into artificial forms.

The Selenka expedition secured along with other fossil remains found in the *Pithecanthropus* beds of Java, a considerable number of bone fragments showing peculiar fracture and worn points suggesting use by primitive man. Blanckenhorn and others who examined these specimens carefully were, however, of the opinion that they might have been produced by fracture of bones carried in a stream or broken by beasts, and that they were not certainly to be attributed to the work of the hominid represented in these strata.

By far the largest representation of evidence suggesting the use of implements by primitive man-like forms near the period of transition from ape to man, is that furnished by the great quantity of flaked flints obtained from strata ranging from Pleistocene down through the late and middle Cenozoic formations of western Europe. These specimens, representing what have been assumed to be the first artificial implements, have been designated as *eoliths,* or the work of the dawn period of implement making. Especially through the work of Rutot,

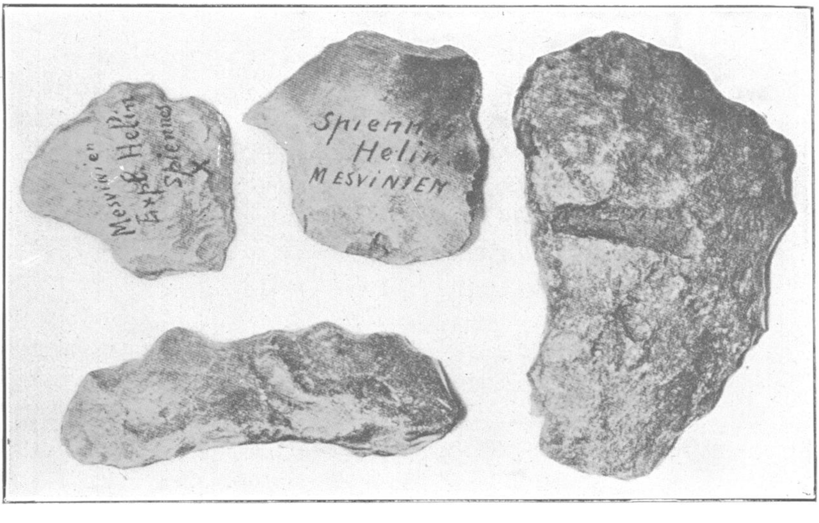

FIG. 17. Eoliths from Belgium. Approximately three-fifths natural size. After MacCurdy.

a considerable variety of flint forms coming from deposits ranging back through the period of *Pithecanthropus* and the Heidelberg man to older time stages have been interpreted as early efforts at preparation of artificial tools.

It is to be assumed that the earliest stone implements used by man were fragments which in their unmodified form were somewhat better fitted for the use of his hand than other more unwieldy or irregular pieces. Presuming that man early learned the cutting power of a rock, it is probable that fragments with sharp edges naturally produced were used at times in place of those with rounded contour, and that specimens thus used and fractured by use may have been found to have an advantage over weathered rocks naturally broken. This may have led to artificial preparation of such broken stones. There should, therefore, be an intermediate stage between unworked natural objects and the earliest tools purposely produced. From the materials representing this type, it would be exceedingly difficult to obtain evidence as to the way in which the objects were formed.

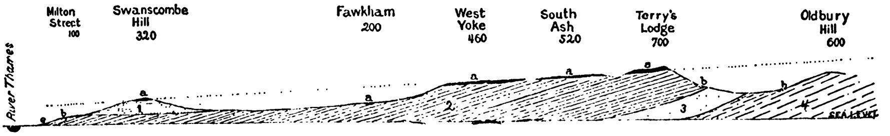

FIG. 18. Section from the Thames to Oldbury Hill near Ightham Kent, England. After MacCurdy, adapted from Prestwich. 1, Tertiary; 2, Chalk; 3, Upper Greensand and Gault;; 4, Lower Greensand. *a*, Red clay with flints—eoliths. *b*, Upper valley gravel—palæoliths. *e*, Low-level valley-gravels—palæoliths.

No scientific controversy in Europe in the last decades has been more warmly contested than that over the artificial or non-artificial character of the eoliths or broken flints from formations of approximately Pliocene age, and in the zone in which one might expect the beginnings of implement making.

Among classic localities for these flints is that of the Kent Plateau, where, near Ightham in the south of England, Mr. Benjamin Harrison through many years has collected a wide range of flint forms from deposit assumed to be of Pliocene age. These eoliths occur in a red clay formation which lies across the edges of several upturned formations of considerable antiquity. Through this plateau there has been cut the valley of the Thames River. In sculpturing out the modern topography, various stages in the cutting of the valley along the streams have left terrace deposits on the banks, in which considerable numbers of flint implements have been found. In the lower levels bordering the valley, the flints represent stages in the history of implement making corresponding to the middle Pleistocene of western Europe. In the upper levels representing the stage before the cutting of the valley, eoliths are obtained and the Pleistocene implements are not represented. There is, then, a historic sequence in the implement making of this region beginning with the stage of the eolith of the upper plateau, and grading through the more advanced stages of implements in the lower terraces.

The eoliths of the Kent Plateau correspond to a period not later, and probably earlier, than that of *Pithecanthropus,* and certainly older than that of the Heidelberg man. It is not improbable that flaked flints of this nature were used by both of these primitive human types. Whether the flints of the Kent Plateau were implements, and whether their origin was through artificial human production is difficult to determine. The fact that they grade insensibly into flaked flints of a type which may have been produced without the intervention of man, does not prove that their form was not due to human influence, and that they were not actually used by man. On the other hand, there is much evidence to indicate that many of the flints of these eolith beds may have been formed without human assistance.

CONCLUSIONS REGARDING SIGNIFICANCE OF EARLIEST HOMINID REMAINS

In concluding this phase of the discussion relating to the earliest traces of beings of our human group, it may be desirable to view in the large the data thus far assembled.

We have seen that remains of man-like forms are not limited to deposits of the present period nor are they found in all formations of the geologic succession. We find the earliest evidences indicating the presence of man occurring at that particular time, and not before the time, when evolution of the group of animals most closely resembling us had reached a stage near to the human type.

We find the earliest humans represented as a part of the normal life of the earth in a period so remote that in our calculation of its date a thousand years seems only as a day. *Pithecanthropus* and the man of Heidelberg were long dead, and had become ashes of a bygone age, before the world saw the beginning of many extended series of events, which changed the form of continents, shifted the earth climate back and forth from arctic to temperate in changes of the Glacial Epoch, and passed over the earth long processions of living generations each in turn enjoying its hour of geologic time and fading out into the night of history. Although of these most ancient humans the earliest preserved traces are very faint, we find them adequate to show that at the time in which they lived our race was represented by beings set off from other primates by their erect bodies, long-striding limbs, hands that were free to build, and a brain that began to plan. And yet we find these forms more beast like and more anthropoid than any type of man at any later time.

So far as our evidence goes, it meets the requirements of those who assume the emergence of man from the animal world in the same manner in which innumerable other organic types have arisen in the long life record as we know it.

The reading of the full story of the advent of man is still to come, and the task of deciphering it will go on into coming centuries. With this must proceed also interpretation of the subsequent stages of man's growth or evolution, of which a brief account will be presented in a later paper.